APPENDIX B: STATISTICAL METHODS:
RADIOACTIVE MATERIALS MONITORING

1. Purpose and Scope

The primary objective of the radioactive materials monitoring program is to identify the release of radioactive materials from the Secure Cells to the hydrogeologic system underlying the facility. This program supplements the RCRA monitoring program, which monitors for changes in general water chemistry, semi-volatile and volatile organics, and inorganic indicator parameters. The design of the statistical methods to be used in analysis of laboratory results from groundwater monitoring for radioactive materials aims to characterize the general background radiochemical properties of the hydrogeologic system from which groundwater samples are to be compared. The methods are also designed to minimize the frequency of false positive results. Descriptive statistics and control chart analyses will be performed on the measured values reported by the laboratory for all radioactivity measurements.

2. Background Database

The background database for sample to background comparisons consists of analytical data from prior to waste acceptance at the facility as well as data from post waste acceptance which have been determined to represent the natural background population of the groundwater surrounding the sampled well, as described in Section 6 of this document. A background population dataset is defined for each parameter tested at each well.

3. Trend and Comparative Analyses

Trend and comparative analyses will be utilized to detect a release from a secure cell into the hydrogeologic environment underlying the facility. Breakthrough charts will be constructed for each sampling event. The breakthrough charts will plot concentration versus time for each analytical parameter at each well. Results which are less than the sample detection limit will be plotted at half of the detection limit. In the case of radioactivity concentrations, the laboratory stated Minimum Detectable Concentration (MDC, the net concentration that has a 95% chance of being detected, as determined by the laboratory) will be used as the detection

limit. For mass concentrations, the laboratory quantitation limit will be used for the detection limit.

Due to the absence of a well defined hydraulic gradient at the site, evaluation of exceedances is completed based solely on an intra-well comparison approach. Combined Shewhart-CUSUM Control Charts will be used to compare the laboratory analytical results for the radiochemistry parameters to the background datasets. The Shewhart control chart provides enhanced detection of large releases, whereas the CUSUM control chart is sensitive to small, gradual increases in parameter concentrations.

3.1 Control Chart Limits

Sample values which exceed the calculated control chart limits constitute a statistically significant increase in parameter concentration (significant increase). Significant increases are discussed further in Section 6 of this document.

The default upper Shewhart limit, SCL^1, and CUSUM control limit, h^1, are set to 4.5 and 5.0, respectively, and the CUSUM parameter, k^1, is set to 1.0. Combined Shewhart-CUSUM control charts will be plotted for each sampling event. The background dataset will be updated with every two years, defining a "control period" of duration two years. The three Shewhart-CUSUM parameters (k, h and SCL) will be adjusted as needed. Any adjustment to these parameters requires an explanation of the basis for the adjustment and the suitability of the new parameter value(s).

1. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*, United States Environmental Protection Agency, 2009.

3.2 Control Chart Assumptions

The control chart approach assumes that the data are independeny and normally distributed about the mean with constant variance. Prior to execution of Control Chart analysis, or other analyses which assume normality of the data, the dataset will be transformed to achieve normality. Determination of a probability model for each dataset will be completed at the onset of each new control period to confirm or adjust the observed transformation requirements of each dataset. Due to the low flow hydrogeologic environment at the facility, sampling frequency will not exceed semi-annual monitoring in order to maintain sample independence.

4. Descriptive Statistics

Descriptive statistics will be generated for each dataset relating the measures of central tendency, dispersion and distribution for that dataset. Following is a list of each measured parameter that will be presented for each radiochemical being analyzed:

- · Number Of Samples
- · Percent Of Detections
- · Arithmetic Mean
- · Standard Deviation from Mean
- · Coefficient of Skewness
- · Upper 95.0% Confidence in Mean
- · Median
- · Minimum Dataset Value
- · Maximum Dataset Value
- · Minimum Detected Value
- · Maximum Detected Value

5. Negative Concentrations

As in all measurements, there is an inherent uncertainty in the measured values of sampling results. Error in the final result can be introduced in the sampling process, in the transport process, and in the laboratory analysis. Much of the uncertainty due to measurement limitations at the laboratory can be quantified, and the laboratory will provide a measure of the uncertainty with the analytical results. Due to the potential for unquantifiable uncertainties, in conjunction with the guarantee that statistical outliers will occur naturally in the background population, resampling of the well shall occur in the event that the statistical comparison results in an exceedance detection, as defined in Section 3 of this document. The purpose of resampling is to reduce the uncertainty associated with the test results and to confirm or deny the exceedance detection.

In the process of laboratory analysis, interference of the natural and normally fluctuating background radiation within the laboratory must be subtracted from the analytically measured radioactivity. Due to the variability of the background radiation subtracted from the sample measurement, a sample with a true radioactivity of at or near zero will occasionally produce measurement results below zero.

There will be no substitution for curie concentration values below the detection limit. In the event that a statistical calculation is mathematically impossible with negative values, such as when logarithmically transforming the dataset, the entire dataset will be shifted by adding a shift constant, which is greater than or equal to the negative of the largest negative number within the dataset. After the statistical calculations are complete, relevant parameters will be reverse shifted by subtracting the shift constant. Following is a list describing parameters that will require a reverse shift:

Descriptive Statistics	Dataset Mean
	Upper 95% Confidence in Mean
	Minimum and Maxumum Dataset Values
	Minimum and Maximum Detected Values
Control Charts	Shewhart Value
	Shewart Control Limit

6. Exceedances and Resampling Events

In the event that a significant increase in parameter concentration is identified, as defined in Section 3 of this document, resampling at the location from which the significant increase occurred will take place within forty-five days of the date that the laboratory analytical results are received. The laboratory will reanalyze the resample for the exceedance parameter. The second sample analysis result will be subjected to the same comparison limit as the first sample. If the second comparison is below the control chart limits, then both the original sample and the resample will be considered as belonging to the background population and their results will be added to the background database. If the second sample result also produces a statistical increase, then the results qualify as a confirmed statistically significant increase in parameter concentration (confirmed statistical increase).

If the CUSUM comparison triggered the significance of the increase, and the Shewhart comparison did not trigger significance, then further action is not necessary until the background has updated and new CUSUM limits are calculated. If, when the new limits are calculated, the CUSUM comparison still triggers significance, then further action is necessary, as described below. If the increase is triggered by a Shewhart failure, then further action is necessary. Further action includes either a demonstration be made that the increase is an artifact caused by an error in sampling, analysis, statistical evaluation or natural variation in the ground water, or the Permittee will Submit to the department in writing, within ninety days of receipt of the analysis, a plan to further investigate the source of the increase in concentration.